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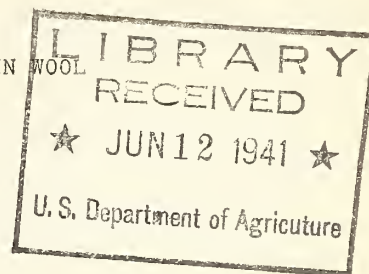
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A RAPID METHOD FOR EXPRESSING MEDULLATION IN WOOL

By

Elroy M. Pohle,
U. S. Bureau of Animal Industry,
Western Sheep Breeding Laboratory,
Dubois, Idaho



Animal-fiber technologists and wool manufacturers have for many years recognized medullation in wool fibers as a defect. However, there is need of a workable method by which the degree of medullation can be expressed with precision and in a manner applicable to sheep breeding programs in which comparative studies are necessary.

Wilson (4) has reviewed the history of medullated fiber research and has developed a macroscopic method of detection. The cross-section method developed by Hardy (1) has also made it possible to detect medullation in wool, and, by making use of the count method described by Hardy and Wolf (2), and by applying the rapid comparator method for determining fineness and variability described by Pohle (3), a method has now been developed by means of which the degree of medullation in wool fibers can be conveniently expressed in percentage.

Materials

In making cross-sections for quality studies of wool at the Western Sheep Breeding Laboratory, Dubois, Idaho, 241 samples showing varying degrees of medullation in wool fibers were selected for use in this study. Photostats were made of these cross-sections, which were later analyzed for fineness and variability as well as for medullation. Medullated wool fibers are very clearly discernible in photostat cross-sections at 500 diameters because the center of the fiber or medulla is white, and the cortex of the wool fiber black. In the microscopic inspection of the cross-sections the medulla is obviously the reverse of this, or black, and the cortex is white.

Basis for Method

Tables 1, 2, and 3 have been compiled respectively for the adjacent, adjacent to loose, and loose degrees of "pack" by using data previously presented by Hardy and Wolf (2). They reported the average number of wool fibers in cross-section for a given mean diameter in microns for a 125 sq. cm. area, magnified at 500 diameters when any one of the previously mentioned degrees of "pack" was used. By knowing the average number of fibers in a 125 sq. cm. area, it is now possible to express degree of medullation in percentage by counting all the medullated fibers appearing inside

of the area, and not touching the area boundaries. To this number were added all alternate medullated fibers that were in contact with the boundaries of the area and lying either outside or inside of the area selected. The total number of medullated fibers are now available for reference to the tables. As an example in table 1, for adjacent pack, if the estimated mean fiber diameter is 22 microns, which, according to Hardy and Kulf (2), contains an average of 104 fibers within a 125 sq. cm. area, and which by actual count shows 13 medullated fibers, then the percentage of medullation can be determined by dividing the number of medullated fibers by the total number of fibers within the area and multiplying by 100 which is in this case 12.5 percent medullation. This is the manner in which the tables were prepared so that it is possible to read directly the percentage for different numbers of medullated fibers.

Application of Method

The cross-section is placed in the micro-projector and a representative area projected onto a receiving screen that contains a 125 sq. cm. rectangular area. In regular routine examination of the cross-section, mean diameter and variability are estimated by the method described by Pohle (3). Then if any medullated fibers are present they are counted in the manner already described and the type of "pack" is estimated. Percentage of medullation is arrived at by referring to the proper table. Thus, if the mean diameter is 22 microns and 13 medullated fibers were counted and the pack was estimated as adjacent, refer to table 1, on the line for 22 microns and the column for 13 medullated fibers which gives the percentage of 12.5 where the line and column intercept.

Test of Method

It is recognized that errors in the percentage of medullation as arrived at by the proposed method might occur due to failure to estimate exactly the mean diameter or degree of "pack." Also it is probable that the number of fibers in the area will vary around the mean which is used in each given case. Therefore, it is necessary to determine if these possibilities actually interfere with the practical accuracy of the proposed method.

A study was made to test the accuracy of determining the percentage of medullation with the method being presented, as compared with the calculated percentage of medullation determined by making actual fiber counts from the photomicrographs of the 241 cross-sections.

By comparing the percentage of medullation arrived at by use of the tables with the calculated, which was based on the actual count, it was found that 80.5 percent of the estimates were within 1 percent of the calculated; 11.6 percent were within 2 percent, and 7.9 were slightly above 2 percent of the calculated. The range of difference between the percentage for the proposed method and calculated appeared to progress as the wool fibers increased in diameter and the medullated fibers increased in number. The mean diameters of the samples studied varied from 18 to 35 microns; the number of medullated fibers in each sample varied from 1 to 52, and the percentage medullation from 0.6 to 91.0. All three types of "pack" were involved.

Table 1

Percentage Medullation in Wool Fibers for 125 Sq. Cm.
Area at 500 Diameters for Adjacent (A) Packing

Mean diameter (microns)	Average no. fibers in 125 sq. cm. area	No. medullated fibers in 125 sq. cm. area																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	20	25		
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%		
16	198.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.6	5.1	5.6	6.1	6.6	7.1	7.6	10.1	12.6		
17	174.0	0.6	1.2	1.7	2.3	2.9	3.5	4.0	4.6	5.2	5.8	6.3	6.9	7.5	8.1	8.6	11.5	14.4		
18	154.0	0.7	1.3	2.0	2.6	3.3	3.9	4.6	5.2	5.8	6.5	7.1	7.8	8.4	9.1	9.7	13.0	16.2		
19	137.0	0.7	1.5	2.2	2.9	3.7	4.4	5.1	5.8	6.6	7.3	8.0	8.8	9.5	10.2	11.0	14.6	18.2		
20	125.0	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0	16.0	20.0		
21	113.0	0.9	1.8	2.7	3.5	4.4	5.3	6.2	7.1	8.0	8.9	9.7	10.6	11.5	12.4	13.3	17.7	22.1		
22	104.0	1.0	1.9	2.9	3.9	4.8	5.8	6.7	7.7	8.7	9.6	10.6	11.5	12.5	13.5	14.4	19.2	24.0		
23	95.0	1.1	2.1	3.2	4.2	5.3	6.3	7.4	8.4	9.5	10.5	11.6	12.6	13.7	14.7	15.8	21.1	26.3		
24	87.0	1.2	2.3	3.5	4.6	5.8	6.9	8.1	9.2	10.3	11.5	12.6	13.8	14.9	16.1	17.2	23.0	28.7		
25	80.0	1.3	2.5	3.8	5.0	6.3	7.5	8.8	10.0	11.3	12.5	13.8	15.0	16.3	17.5	18.8	25.0	31.3		
26	74.0	1.4	2.7	4.1	5.4	6.8	8.1	9.5	10.8	12.2	13.5	14.9	16.2	17.6	18.9	20.3	27.0	33.8		
27	69.0	1.5	2.9	4.4	5.8	7.3	8.7	10.1	11.6	13.0	14.5	15.9	17.4	18.8	20.3	21.7	29.0	36.2		
28	64.0	1.6	3.1	4.7	6.3	7.8	9.4	10.9	12.5	14.1	15.6	17.2	18.8	20.3	21.9	23.4	31.3	39.1		
29	60.0	1.7	3.3	5.0	6.7	8.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0	21.7	23.3	25.0	33.3	41.7		
30	56.0	1.8	3.6	5.4	7.1	8.9	10.7	12.5	14.3	16.1	17.9	19.6	21.4	23.2	25.0	26.8	35.7	44.6		
31	52.5	1.9	3.8	5.7	7.6	9.6	11.4	13.3	15.2	17.1	19.1	21.0	22.9	24.8	26.7	28.6	38.1	47.6		
32	49.0	2.0	4.1	6.1	8.2	10.2	12.2	14.3	16.3	18.4	20.4	22.5	24.5	26.5	28.6	30.6	40.8	51.0		
33	46.0	2.2	4.4	6.5	8.7	10.9	13.0	15.2	17.4	19.6	21.7	23.9	26.1	28.3	30.4	32.6	43.5	54.3		
34	43.5	2.3	4.6	7.0	9.2	11.6	13.8	16.1	18.4	20.7	23.0	25.3	27.6	29.9	32.2	34.5	46.0	57.5		
35	41.0	2.4	4.9	7.3	9.8	12.2	14.6	17.1	19.5	22.0	24.4	26.8	29.3	31.7	34.2	36.6	48.8	61.0		
36	39.0	2.6	5.1	7.7	10.3	12.8	15.4	18.0	20.5	23.1	25.6	28.2	30.8	33.3	35.9	38.5	51.3	64.1		
37	37.0	2.7	5.4	8.1	10.8	13.5	16.2	18.9	21.6	24.3	27.0	29.7	32.4	35.1	37.8	40.5	54.1	67.6		
38	35.0	2.9	5.7	8.6	11.4	14.3	17.1	20.0	22.9	25.7	28.6	31.4	34.3	37.1	40.0	42.9	57.1	71.4		
39	33.0	3.0	6.1	9.1	12.1	15.2	18.2	21.2	24.2	27.3	30.3	33.3	36.4	39.4	42.4	45.5	60.6	75.8		
40	31.0	3.3	6.5	9.7	12.9	16.1	19.4	22.6	25.8	29.0	32.3	35.5	38.7	41.9	45.2	48.4	64.5	80.6		

Table 2

Percentage Medullation in Wool Fibers for 125 Sq. Cm. Area
at 500 Diameters for Adjacent to Loose (AL) Packing

Mean no. fibers in 125 sq. cm. area	No. medullated fibers in 125 sq. cm. area																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	20	25	%	%	
18	153.0	0.7	1.3	2.0	2.6	3.3	3.9	4.6	5.2	5.9	6.5	7.2	7.8	8.5	9.2	9.8	13.1	16.3		
19	136.0	0.7	1.5	2.2	2.9	3.7	4.4	5.1	5.9	6.6	7.4	8.1	8.8	9.6	10.3	11.0	14.7	18.4		
20	124.0	0.8	1.6	2.4	3.2	4.0	4.8	5.7	6.5	7.3	8.1	8.9	9.7	10.5	11.3	12.1	16.1	20.2		
21	112.5	0.9	1.8	2.7	3.6	4.4	5.3	6.2	7.1	8.0	8.9	9.8	10.7	11.6	12.4	13.3	17.8	22.2		
22	102.5	1.0	2.0	2.9	3.9	4.9	5.9	6.8	7.8	8.8	9.8	10.7	11.7	12.7	13.7	14.6	19.5	24.4		
23	93.5	1.1	2.1	3.2	4.3	5.4	6.4	7.5	8.6	9.6	10.7	11.8	12.8	13.9	15.0	16.0	21.4	26.7		
24	85.5	1.2	2.3	3.5	4.7	5.9	7.0	8.2	9.4	10.5	11.7	12.9	14.0	15.2	16.4	17.5	23.4	29.2		
25	78.5	1.3	2.6	3.8	5.1	6.4	7.6	8.9	10.2	11.5	12.7	14.0	15.3	16.6	17.8	19.1	25.5	31.8		
26	73.0	1.4	2.7	4.1	5.5	6.9	8.2	9.6	11.0	12.3	13.7	15.1	16.4	17.8	19.2	20.6	27.4	34.2		
27	67.5	1.5	3.0	4.4	5.9	7.4	8.9	10.4	11.9	13.3	14.8	16.3	17.8	19.3	20.7	22.2	29.6	37.0		
28	62.5	1.6	3.2	4.8	6.4	8.0	9.6	11.2	12.8	14.4	16.0	17.6	19.2	20.8	22.4	24.0	32.0	40.0		
29	58.0	1.7	3.5	5.2	6.9	8.6	10.3	12.1	13.8	15.5	17.2	19.0	20.7	22.4	24.1	25.9	34.5	43.1		
30	54.0	1.9	3.7	5.6	7.4	9.3	11.1	13.0	14.8	16.7	18.5	20.4	22.2	24.1	25.9	27.8	37.0	46.3		
31	50.5	2.0	4.0	5.9	7.9	9.9	11.9	13.9	15.8	17.8	19.8	21.8	23.8	25.7	27.7	29.7	39.6	49.5		
32	47.0	2.1	4.3	6.4	8.5	10.6	12.8	14.9	17.0	19.2	21.3	23.4	25.5	27.7	29.8	31.9	42.6	53.2		
33	44.5	2.3	4.5	6.7	9.0	11.2	13.5	15.7	18.0	20.2	22.5	24.7	27.0	29.2	31.5	33.7	44.9	56.2		
34	42.0	2.4	4.8	7.1	9.5	11.9	14.3	16.7	19.1	21.4	23.8	26.2	28.6	31.0	33.3	35.7	47.6	59.5		
35	40.0	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	50.0	62.5		
36	37.5	2.7	5.3	8.0	10.7	13.3	16.0	18.7	21.3	24.0	26.7	29.3	32.0	34.7	37.3	40.0	53.3	66.7		
37	35.5	2.8	5.6	8.5	11.3	14.1	16.9	19.7	22.5	25.4	28.2	31.0	33.8	36.6	39.4	42.3	56.3	70.4		
38	33.5	3.0	6.0	9.0	11.9	14.9	17.9	20.9	23.9	26.9	29.9	32.8	35.8	38.8	41.8	44.8	59.7	74.6		
39	31.5	3.2	6.4	9.5	12.7	15.9	19.1	22.2	25.4	28.6	31.8	34.9	38.1	41.3	44.4	47.6	63.5	79.4		
40	30.0	3.3	6.7	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0	43.3	46.7	50.0	66.7	83.3		

Table 3

Percentage Medullation in Wool Fibers for 125 Sq. Cm.
Area at 500 Diameters for Loose (L) Packing

Mean diameter in 125 sq. (microns)	Average no. fibers cm. area	No. medullated fibers in 125 sq. cm. area																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	20	25	%	%	
18	151.0	0.7	1.3	2.0	2.7	3.3	4.0	4.6	5.3	6.0	6.6	7.3	8.0	8.6	9.3	9.9	13.2	16.6	%	%	
19	135.0	0.7	1.5	2.2	3.0	3.7	4.4	5.2	5.9	6.7	7.4	8.2	8.9	9.6	10.4	11.1	14.8	18.5	%	%	
20	121.0	0.8	1.7	2.5	3.3	4.1	5.0	5.8	6.6	7.4	8.3	9.1	9.9	10.7	11.6	12.4	16.5	20.7	%	%	
21	109.0	0.9	1.8	2.8	3.7	4.6	5.5	6.4	7.3	8.3	9.2	10.1	11.0	11.9	12.8	13.8	18.3	22.9	%	%	
22	98.0	1.0	2.0	3.1	4.1	5.1	6.1	7.1	8.2	9.2	10.2	11.2	12.2	13.3	14.3	15.3	20.4	25.5	%	%	
23	88.5	1.1	2.3	3.4	4.5	5.7	6.8	7.9	9.0	10.2	11.3	12.4	13.6	14.7	15.8	17.0	22.6	28.2	%	%	
24	80.5	1.2	2.5	3.7	5.0	6.2	7.5	8.7	9.9	11.2	12.4	13.7	14.9	16.2	17.4	18.6	24.8	31.1	%	%	
25	73.5	1.4	2.7	4.1	5.4	6.8	8.2	9.5	10.9	12.2	13.6	15.0	16.3	17.7	19.1	20.4	27.2	34.0	%	%	
26	68.0	1.5	2.9	4.4	5.9	7.4	8.8	10.3	11.8	13.2	14.7	16.2	17.7	19.1	20.6	22.1	29.4	36.8	%	%	
27	62.5	1.6	3.2	4.8	6.4	8.0	9.6	11.2	12.8	14.4	16.0	17.6	19.2	20.8	22.4	24.0	32.0	40.0	%	%	
28	57.0	1.8	3.5	5.3	7.0	8.8	10.5	12.3	14.0	15.8	17.5	19.3	21.1	22.8	24.6	26.3	35.1	43.9	%	%	
29	52.0	1.9	3.9	5.8	7.7	9.6	11.5	13.5	15.4	17.3	19.2	21.2	23.1	25.0	26.9	28.9	38.5	48.1	%	%	
30	48.0	2.1	4.2	6.3	8.3	10.4	12.5	14.6	16.7	18.8	20.8	22.9	25.0	27.1	29.2	31.3	41.7	52.1	%	%	
31.	44.5	2.3	4.5	6.7	9.0	11.2	13.5	15.7	18.0	20.2	22.5	24.7	27.0	29.2	31.5	33.7	44.9	56.2	%	%	
32	42.0	2.4	4.8	7.1	9.5	11.9	14.3	16.7	19.1	21.4	23.8	26.2	28.6	31.0	33.3	35.7	47.6	59.5	%	%	
33	40.0	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	50.0	62.5	%	%	
34	38.0	2.6	5.3	7.9	10.5	13.2	15.8	18.4	21.1	23.7	26.3	29.0	31.6	34.2	36.8	39.5	52.6	65.8	%	%	
35	36.0	2.8	5.6	8.3	11.1	13.9	16.7	19.4	22.2	25.0	27.8	30.6	33.3	36.1	38.9	41.7	55.6	69.4	%	%	
36	34.0	2.9	5.9	8.8	11.8	14.7	17.7	20.6	23.5	26.5	29.4	32.4	35.3	38.2	41.2	44.1	58.8	73.5	%	%	
37	32.0	3.1	6.3	9.4	12.5	15.6	18.8	21.9	25.0	28.1	31.3	34.4	37.5	40.6	43.8	46.9	62.5	78.1	%	%	
38	30.0	3.3	6.7	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0	43.3	46.7	50.0	66.7	83.3	%	%	
39	28.0	3.6	7.1	10.7	14.3	17.9	21.4	25.0	28.6	32.1	35.7	39.3	42.9	46.4	50.0	53.6	71.4	89.3	%	%	
40	26.0	3.9	7.7	11.5	15.4	19.2	23.1	26.9	30.8	34.6	38.5	42.3	46.2	50.0	53.9	57.7	76.9	96.2	%	%	

The relation between the percentages arrived at by the proposed method of expressing medullation and those by the calculated method is shown by a correlation coefficient of 0.99, which indicates the consistency of agreement. The above tests show that the percentage of medullation may be determined by the proposed method with accuracy adequate for the application of this method to sheep breeding programs.

It has been found that around 60 samples of wool can be cross-sectioned and appraised for fineness, variability, and percentage medullation by one operator in a 7-hour day when this method is used in conjunction with the rapid comparator method, whereas only 40 samples can be analyzed in a day if the count method is used.

Summary

1. A rapid method has been described for expressing medullation in wool samples in percentage.
2. This method is easily used with the rapid comparator method, which makes it possible to determine fineness, variability, and medullation at the same operation.
3. This method has been shown to be adequately accurate for application to problems involving the study of medullation in fleeces on a comparative basis.

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